CARLO GAVAZZI SPACE SpA

ACOP

Doc. Type: PLAN			*DRD N°:* E08
Doc. N°: **ACP-PL-CGS-008**	*Issue:* **1**	*Date:* **Oct. 2005**	*Page* **1** *Of* **19**
Title : **ACOP MAINTENANCE PLAN**			

	Name & Function	*Signature*	*Date*
Prepared by:	ACOP Team		
Approved by:	M. Grilli D. Laplena C. Cinquepalmi		
Application authorized by:	C. Pini		
Customer / Higher Level Contractor			
Accepted by:			
Approved by:			

DISTRIBUTION LIST	N	A	I
Internal			
ACOP Team	1	X	
External			
S. Pignataro (ASI)	1		X

N=Number of copy A=Application I=Information

Data Management: ..... *Signature* *Date*

File: ACP-PL-CGS-008 Is1.doc

CHANGE RECORD			
ISSUE	*DATE*	*CHANGE AUTHORITY*	*REASON FOR CHANGE AND AFFECTED SECTIONS*
1	October 2005	-	First Issue

LIST OF VALID PAGES									
PAGE	*ISSUE*	*PAGE*	*ISSUE*	*PAGE*	*ISSUE*	*PAGE*	*ISSUE*	*PAGE*	*ISSUE*
1 - 19	1								

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

1. SCOPE AND INTRODUCTION

Scope of this document is to provide the maintenance plan of the ACOP system according to [RD3]. This document describes maintenance concept, maintenance requirements and basic assumptions relative to maintenance. Details about operations planned in this document can be found in the ACOP Operational Report.

The following types of maintenance have been identified and described:

- pre-launch maintenance
- pre- and post-installation maintenance
- preventive maintenance (nominal operations)
- post-failure maintenance (non-nominal operations)

All the ACOP maintenance operations are safe in accordance with NSTS 18798B Interpretation Letter MA2-00-038.

1.1 DOCUMENTS

1.1.1 APPLICABLE DOCUMENT

AD	Doc. Number	Issue / Date	Rev.	Title / Applicability
1	SSP 52000-IDD-ERP	D / 6.08.03		EXpedite the PRocessing of Experiments to Space Station (EXPRESS) Rack Payloads Interface Definition Document
2	NSTS/ISS 13830	C / 01.12.1996		Implementation Procedures for Payloads System Safety Requirements – For Payloads Using the STS & ISS.
3	JSC 26493	17.02.1995		Guidelines for the preparation of payload flight safety data packages and hazard reports.
4	SSP 50004	April 1994		Ground Support Equipment Design requirements
5	SSP-52000-PDS	March 1999	B	Payload Data Set Blank Book
6	SSP 57066	October 28, 2003		Standard Payload Integration Agreement for EXPRESS/WORF Rack Payloads
7	GD-PL-CGS-001	3 / 17.03.99		Product Assurance & Rams Plan
8	SSP 52000 PAH ERP	November 1997		Payload Accommodation Handbook for EXPRESS Rack
9	SSP 50184	D / February 1996		Physical Media, Physical Signaling & link-level Protocol Specification for ensuring Interoperability of High Rate Data Link Stations on the International Space Program
10	SSP 52050	D / 08.06.01		S/W Interface Control Document for ISPR ***ONLY FOR HRDL, SECTION 3.4 ***
11	ECSS-E-40	A / April 1999	13	Software Engineering Standard
12	AMS02-CAT-ICD-R04	29.08.2003	04	AMS02 Command and Telemetry Interface Control document. Section AMS-ACOP Interfaces
13	SSP 52000-PVP-ERP	Sept. 18, 2002	D	Generic Payload Verification Plan EXpedite the PRocessing of Experiments to Space Station (EXPRESS) Rack Payloads
14	NSTS 1700.7B	Rev. B Change Packet 8 / 22.08.00		Safety Policy and Requirements for Payloads using the STS
15	NSTS 1700.7B Addendum	Rev. B Change Packet 1 / 01.09.00		Safety Policy and Requirements for Payloads using the International Space Station
16	SSP 52005	Dec. 10, 1998		Payload Flight equipment requirements and guidelines for safety critical structures
17	NSTS 18798B	Change Packet 7 10.00		Interpretation of NSTS Payload Safety Requirements
18	MSFC-HDBK-527	15.11.86	E	Materials selection list for space hardware systems Materials selection list data
19	GD-PL-CGS-002	1 / 12.02.99		CADM Plan
20	GD-PL-CGS-004	2 / 07.04.03		SW Product Assurance Plan
21	GD-PL-CGS-005	2 / 09.05.03		SW CADM Plan

Table 1-1 Applicable Documents

1.1.2 REFERENCE DOCUMENT

RD	Doc. Number	Issue / Date	Rev.	Title
1	GPQ-MAN-02	1		Commercial, Aviation and Military (CAM) Equipment Evaluation Guidelines for ISS Payloads Use
2	BSSC (96)2	1 / May 96		Guide to applying the ESA software engineering standards to small software projects
3	GPQ-MAN-01	2 / December 98		Documentation Standard for ESA Microgravity Projects
4	MS-ESA-RQ-108	1 / 28 Sept. 2000		Documentation Requirements For Small And Medium Sized MSM Projects
5	PSS-05			Software Engineering Standards
6	GPQ-010	1 / May 95	A	Product Assurance Requirements for ESA Microgravity Payload. Including CN 01.
7	GPQ-010-PSA-101	1		Safety and Material Requirements for ESA Microgravity Payloads
8	GPQ-010-PSA-102	1		Reliability and Maintainability for ESA Microgravity Facilities (ISSA). Including CN 01
9	SSP 52000-IDD-ERP	E / 09/09/03		EXpedite the PRocessing of Experiments to Space Station (EXPRESS) Rack Payloads Interface Definition Document
10	ACD-Requirements-Rev-BL	September 2005	Base Line	ACOP Common Design Requirements Document
11	ECSS-Q-60-11A	1 / 7 Sept. 2004		De-rating and End-of-life Parameter Drifts – EEE Components
12	ACP-PL-CGS-002	1 / 28 July 2004		ACOP PA Plan
13	ACP-RP-CGS-002	2 / October 2005		ACOP Operational Analysis Report
14	ACP-RP-CGS-003	2 / October 2005		ACOP Design Report
15	ACP-RP-CGS-004	2 / October 2005		ACOP Electrical Analysis and Design Report
16	ACP-RP-CGS-005	2 / October 2005		ACOP Structural Analysis and Design Report
17	ACP-RP-CGS-006	2 / October 2005		ACOP Thermal Analysis and Design Report
18	ACP-RP-CGS-007	1 / October 2005		ACOP Fracture Control Report
19	ACP-TN-CGS-001	2 / October 2005		ACOP FMECA and SPF List

Table 1-2 Reference Documents

1.2 DEFINITIONS AND ACRONYMS

A

AAA	Avionics Air Assembly
ABCL	As-Built Configuration data List
ACOP	AMS-02 Crew Operation Post
ACOP-SW	ACOP Flight Software
ADP	Acceptance Data Package
AMS-02	Alpha Magnetic Spectrometer 02
APS	Automatic Payload Switch
AR	Acceptance Review
ASI	Agenzia Spaziale Italiana *(Italian Space Agency)*
ATP	Authorization To Proceed

B

BC	Bus Coupler
BDC	Baseline Data Collection
BDCM	Baseline Data Collection Model

C

CAD	Computer Aided Design
CCB	Configuration Control Board
CCSDS	Consultative Committee on Space Data Standards (standard format for data transmission)
C&DH	Command & Data Handling
CDR	Critical Design Review
CGS	Carlo Gavazzi Space
CI	Configuration Item
CIDL	Configuration Item data List
CM	Configuration Management
COTS	Commercial Off The Shelf
cPCI	CompactPCI (Euro Card sized standard interface to the PCI)
CSCI	Computer Software Configuration Item
CSIST	Chung Shan Institute of Science and Technology

D

DCL	Declared Components List
DIL	Deliverable Items List
DIO	Digital Input / Output
DML	Declared Materials List
DMPL	Declared Mechanical Parts List
DPL	Declared Processes List
DRB	Delivery Review Board
DRD	Document Requirements Description

E

EEE	Electrical, Electronic & Electromechanical
EGSE	Electrical Ground Support Equipment
EM	Engineering Model
ER	EXPRESS Rack
ERL	EXPRESS Rack Laptop
ERLC	EXPRESS Rack Laptop Computer
ERLS	EXPRESS Rack Laptop Software
EMC	Electro-Magnetic Compatibility
ESA	European Space Agency
EXPRESS	EXpedite the PRocessing of Experiments to Space Station

F

FEM	Finite Element Model
FFMAR	Final Flight Model Acceptance Review
FLASH	Rewriteable persistent computer memory
FM	Flight Model
FMECA	Failure Modes, Effects & Criticalities Analysis
FPGA	Field Programmable Gate Array

FSM	Flight Spare Model

G

GIDEP	Government Industry Data Exchange Program
GSE	Ground Support Equipment

H

HCOR	HRDL Communications Outage Recorder
HD	Hard Drive
HDD	Hard Disk Drive
HRDL	High Rate Data Link
HRFM	High Rate Frame Multiplexer
HW	Hardware

I

ICD	Interface Control Document
I/F	Interface
IRD	Interface Requirements Document
ISPR	International Space-station Payload Rack
ISS	International Space Station

J

JSC	Johnson Space Center

K

KIP	Key Inspection Point
KSC	Kennedy Space Center
KU-Band	High rate space to ground radio link

L

LAN	Local Area Network
LCD	Liquid Crystal Display
LFM	Low Fidelity Model
LRDL	Low Rate Data Link

M

MDL	Mid-Deck Locker
MGSE	Mechanical Ground Support Equipment
MIP	Mandatory Inspection Point
MMI	Man Machine Interface
MPLM	Multi-Purpose Logistic Module
MRDL	Medium Rate Data Link

N

NA	Not Applicable
NASA	National Aeronautics and Space Administration
NCR	Non Conformance Report
NDI	Non Destructive Inspection
NRB	Non-conformance Review Board
NSTS	National Space Transportation System (Shuttle)

O

OLED	Organic Light-Emitting Diode
ORU	Orbital Replacement Unit

P

PA	Product Assurance
PCB	Printed Circuit Board
PCI	Peripheral Component Interconnect (personal computer bus)
PCS	Personal Computer System
PDR	Preliminary Design Review
PEHB	Payload Ethernet Hub Bridge
PEHG	Payload Ethernet Hub Gateway

PFMAR	Preliminary Flight Model Acceptance Review
PLMDM	Payload Multiplexer De-Multiplexer
PMC	PCI (Peripheral Component Interconnect) Mezzanine Card
PMP	Parts, Materials & Processes
PROM	Programmable Read Only Memory
PS	Power Supply

Q

QM	Qualification Model

R

RFA	Request For Approval
RFD	Request For Deviation
RFW	Request For Waiver
RIC	Rack Interface Controller
ROD	Review Of Design
ROM	Read Only Memory
RX	Reception

S

SATA	Serial Advanced Transfer Architecture (disk interface)
S-Band	Space to ground radio link
SBC	Single Board Computer
SC MDM	Station Control Multiplexer De-Multiplexer
ScS	Suitcase Simulator
SDD	Solid-state Disk Drive
SIM	Similarity Assessment
SIO	Serial Input Output
SOW	Statement Of Work
SPF	Single Point Failure
SRD	Software Requirements Document
STS	Space Transportation System (Shuttle)
SW	Software

T

TBC	To Be Confirmed
TBD	To Be Defined
TBDCM	Training & Baseline Data Collection Model
TBDCMAR	TBDCM Acceptance Review
TBP	To Be Provided
TCP/IP	Transmission Control Protocol / Internet Protocol
TFT	Thin Film Transistor
TM	Telemetry
TRB	Test Review Board
TRR	Test Readiness Review
TRM	Training Model
TX	Transmission

U

UIP	Utility Interface Panel
UMA	Universal Mating Assembly
USB	Universal Serial Bus

#

100bt	Ethernet 100Mbit Specification
1553	Reliable serial communications bus

2. DESCRIPTION OF ACOP.

The ACOP System is a reliable special purpose computer intended to fly on the International Space Station (ISS) as a payload installed into an EXPRESS ISPR in the NASA US laboratory module. The main objective of ACOP is to provide an ISS Internal Facility capable of supporting the AMS-02 experiment by recording the Science data.

In particular, ACOP shall allow a more flexible and efficient use of ISS telemetry downlink, providing a backup of data generated by AMS-02 and preventing, in this way, possible losses of valuable data. In addition, ACOP provides a control and monitoring interface for the on-board crew to the external AMS payload. It also permits large software uploads into AMS.

ACOP is not designed to provide safety critical commands to AMS-02.

The ACOP system shall be installed in the U.S. Laboratory Module, on the ISS, in one EXPRESS rack (see, for reference, Figure 2-1).

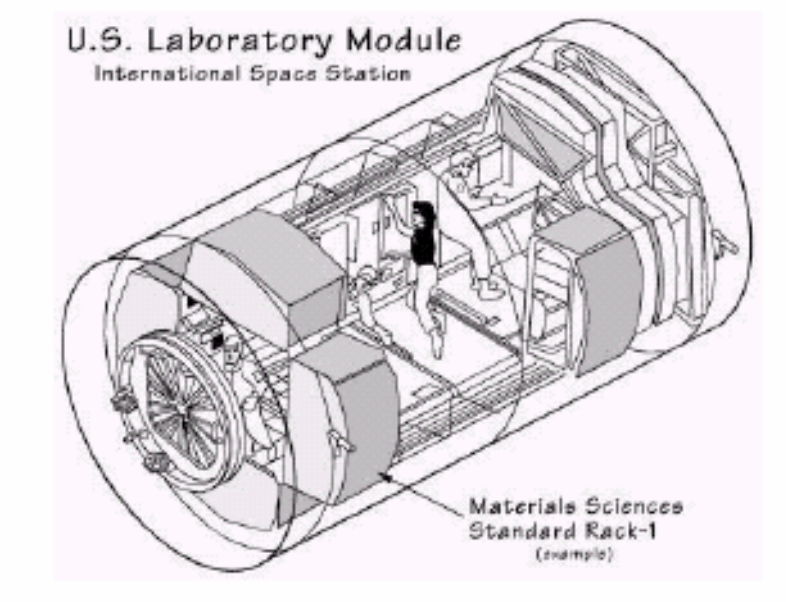

Figure 2-1 US Lab

The standard configuration of an EXPRESS Rack is commonly known as 8/2. This means the rack can accommodate eight ISS Locker / Middeck Locker (MDL) units and two International Subrack Interface Standard (ISIS) units, as shown in Figure 2-2 and Figure 2-3. Figure 2-4 shows ACOP installed in such a rack (the location within the rack is just an example, the actual location will be determined by the ISS program).

On-board spare parts, including hard drives shall be accommodated in a standard soft bag (CTB).

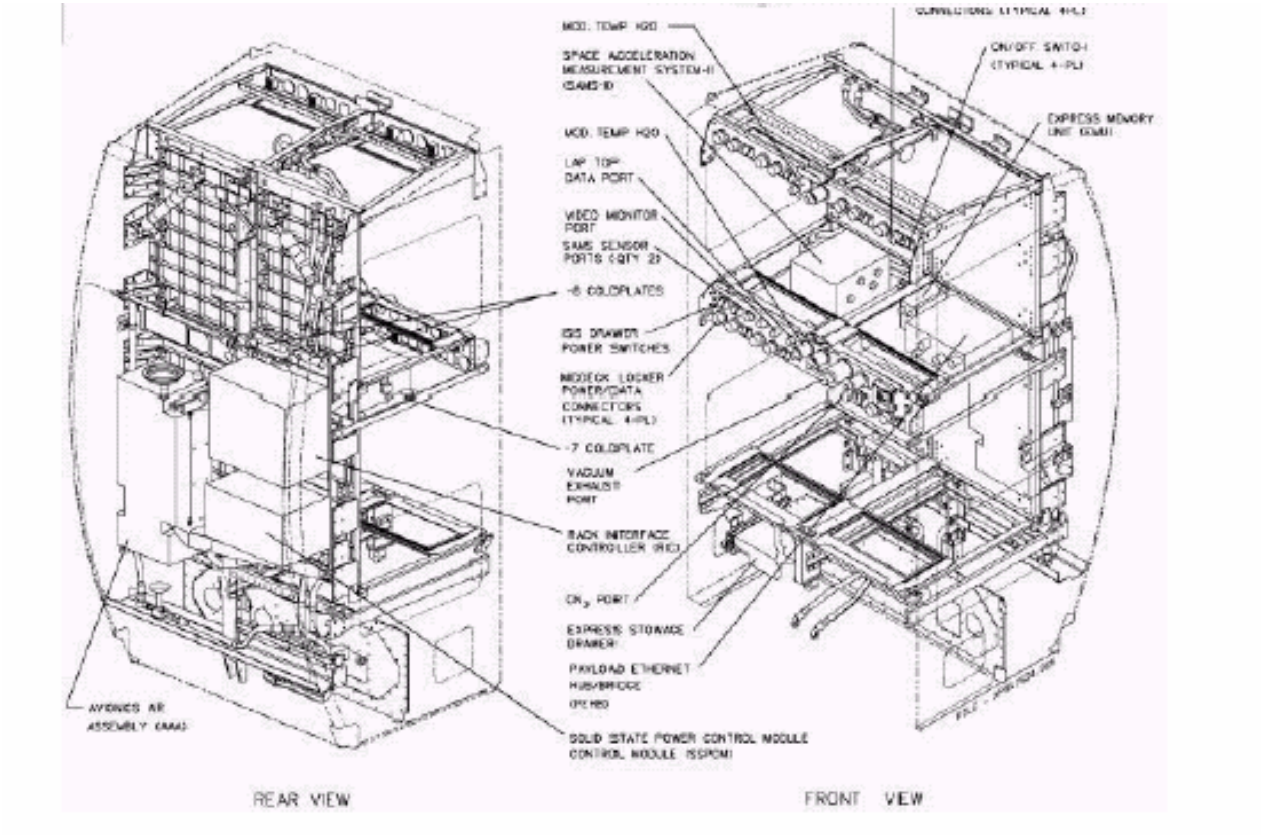

Figure 2-2 Example of an EXPRESS Rack (3D view)

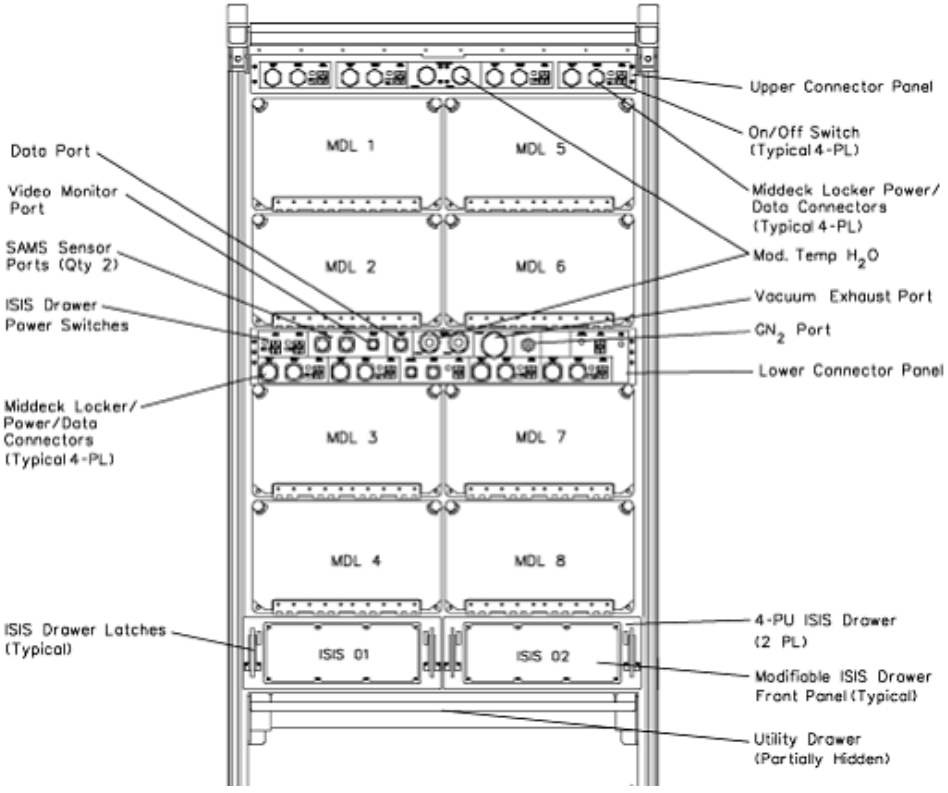

Figure 2-3 Example of an EXPRESS Rack (front view)

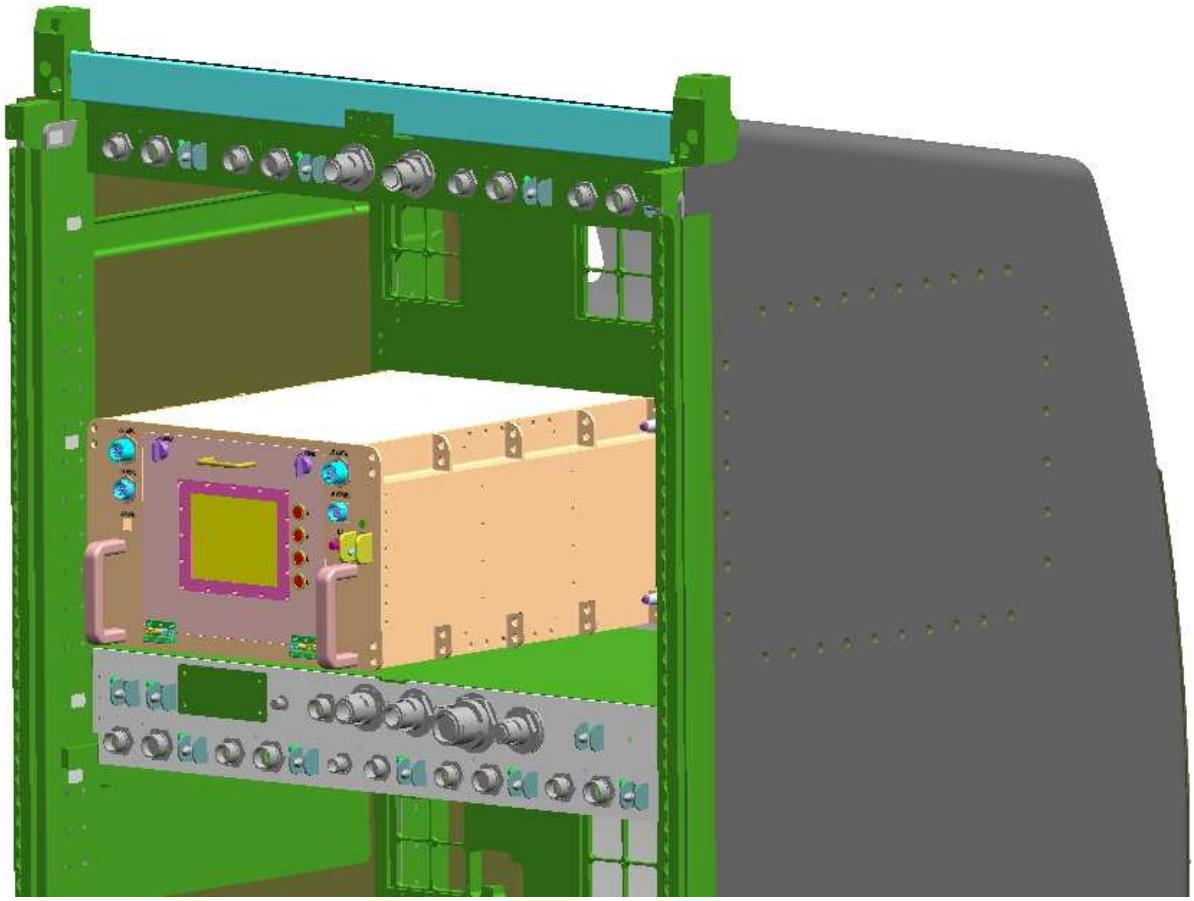

Figure 2-4 ACOP installed in an EXPRESS Rack (example of possible location)

ACOP provides these services:

1. On-orbit recording mechanism for large volumes of data at high rates
2. Play back for downlink of the recorded data at high rates
3. A crew interface for complex experiments
4. General computing facilities
5. Alternate bi-directional commanding path via the HRDL interface

ACOP will initially support a state-of-the-art particle physics detector, the Alpha Magnetic Spectrometer (AMS-02) experiment. AMS-02 uses the unique environment of space to study the properties and origin of cosmic particles and nuclei including antimatter and dark matter, to study the actual origin of the universe and potentially to discover antimatter stars and galaxies.

After the AMS-02 experiment, ACOP will remain in the US Lab as a general use computer for recording and managing large data volumes on the ISS. It will also allow a flexible and extensible control and monitoring interface for future payloads and, by using the large buffering capacity (> 1 TB), it will improve the data communication between Earth and the Space Station.

In addition to the ACOP system itself, shown in Figure 2-5 and Figure 2-6, a stowage bag will be sent to ISS with additional hard drives that can be exchanged with the hard drives in ACOP. From time to time the astronauts will perform this exchange enabling ACOP to record all of the AMS-02 data onto fresh hard drives. Once recorded, data will not be overwritten; rather the hard drives will be transported to ground as a permanent archive. The stowage bag will also contain spare parts for ACOP.

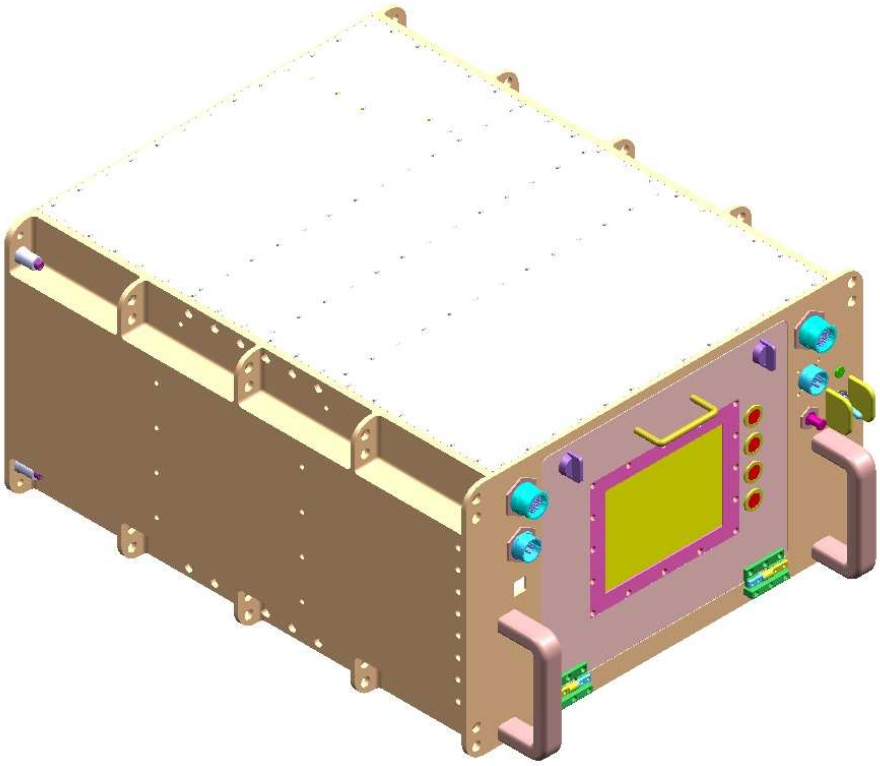

Figure 2-5 ACOP General Front View

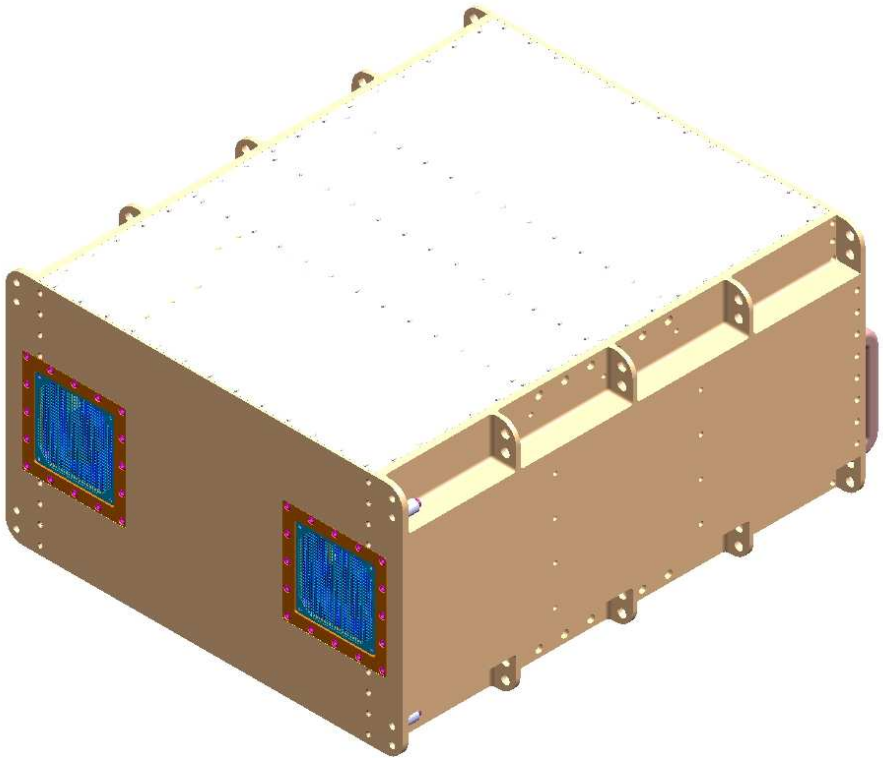

Figure 2-6 ACOP General Rear View

2.1 FUNCTION AND PURPOSE OF ACOP

ACOP has been designed to fulfill the requirements generated by the AMS-02 Collaboration. See the ACOP Common Design Requirements Document (document number: ACD-Requirements-Rev-BL, revision: baseline, date: September 2005) and the ACOP System Specification (document number: ACP-SY-CGS-001, issue: 3, date: March 2005) for a detailed description of the requirements.

The main characteristics of ACOP are summarized here below:

Capacities

1. Operates effectively in the ISS space environment.
2. Creates, on-orbit, an archive of all AMS-02 science data on removable and transportable media, using high capacity (200 GB or more) SATA hard drives.
3. Provides (based on an average data rate of 2Mbit/s) at least 20 days of recording capacity without crew intervention[1].
4. Provides (based on an average data rate of 2Mbit/s) at least 120 days of on board recording media capacity within an additional single mid-deck locker equivalent soft sided storage unit[2].
5. Recorded data is an irreplaceable archive of science data. Once recorded, data will not be overwritten; rather the hard drives will be transported to ground as a permanent archive.

Rates

6. For recording ACOP supports an orbital average data rate of at least 4Mbit/s with bursts of up to 20Mbit/s[3].
7. Supports the playback of recorded data to ground systems at selectable data rates up to at least 20Mbit/s sustained while simultaneously recording at prescribed rates (per 6.).
8. Supports an alternate AMS-02 ground commanding and housekeeping report path via the HRDL interface.
9. Supports ACOP to AMS-02 commanding at selectable data rates up to at least 20Mbit/s sustained. No requirement for simultaneous recording or playback operations at higher rates.

Interfaces

10. Provides a continuous operations display of ad hoc AMS-02 data and ACOP status for the ISS crew to monitor, via a LCD on the front panel.
11. Provides a continuous means for the ISS crew to issue ad hoc commands immediately to ACOP and to AMS-02 (without the need to un-stow or attach external equipment), by using accessible push-buttons on the front panel.
12. Provides an exhaustive diagnostic, monitoring and operations environment via the EXPRESS laptop computer.

Form

13. Housed within an EXPRESS rack locker and based on a CompactPCI 6U form factor.
14. Crew serviceable for hardware upgrades and repairs.
15. Crew serviceable for software upgrades and repairs.
16. Upgradeable and expandable using COTS subsystems.
17. Provides support of ISS system upgrades (e.g. 100bt MRDL follow on systems).

---

[1] Durations indicated are completely dependent on application implementation.

[2] See note 1.

[3] The AMS-02 experiment has been designed to meet its physics goals when producing data at an average rate of 2MBit/s. Data is produced continuously. However, the physics that will be measured is unknown, and so are the peak and average data rates − 2Mbit/s average is the best estimate. Within AMS-02 a four-fold redundant 1GByte buffer (JBU) is located to smooth the data flow and to allow for short term (less than an hour) interruptions in the data output from AMS, for example when the hard disk drives are being swapped within ACOP. After any such interruption, the data rate capability in ACOP must be able to make up for the lost time while not falling behind on the fresh data. Therefore ACOP is able to process data at a rate of at least twice the average data rate from AMS, namely 4Mbit/s.

18. ACOP is to weigh less than 35.5 kg without disks (launch weight)[4].
19. ACOP to consume less than 200 W (at 28Vdc)[5]
20. Launch compatible with MLPM mounting and dynamics.

2.2 UTILIZATION CONCEPT

The following are the key points of the ACOP operational concept as it pertains to the AMS-02 mission:

- ACOP is principally a ground operated payload
- ACOP provides the mechanism for the crew to monitor and control AMS-02. Both front panel and EXPRESS Rack laptop based interfaces are supported.
- ACOP is powered and active whenever AMS-02 is active. Only short (< 8 hours) outages.
- ACOP has continuous direct access to two physical HRDL connections (1 Tx/Rx pair plus an additional Tx, via UIP J7 connectors in other racks). By means of these interfaces:
  a. maintains a continuous Tx/Rx connection via APS to AMS
  b. provides intermittent, schedulable Tx connection for downlink.

  The additional Tx connection may be replaced by connection to the upgraded 100BaseT MRDL, when available.
- The AMS-02 Tx connection may be tee'd within the APS to the HRFM/KU for direct downlink.
- As KU access is available, ACOP will be commanded to use its additional TX connection to down link data. ACOP will have the ability to burst this transmission (~20Mbits/sec).
- All data transmitted by AMS-02 is recorded onto ACOP hard drives as a master copy of the AMS-02 science data.
- When ACOP has acknowledged that the data is recorded, AMS-02 can release that data from its buffers.
- The four installed hard drives will require periodic exchange by the ISS crew from the onboard stock of empty drives (30 minute operation about every 20 days)
- A batch of 20 hard drives provides at least 120 days of recording capacity.
- New batches of hard drives will be delivered to ISS and the original master copies of the AMS-02 data will be returned to earth.

[4] See ACOP Design Report for the actual mass budget
[5] See ACOP Design Report for the actual power budget

3. ACOP MAINTENANCE

ACOP has been designed to maximize the possibility of maintenance both before launch and on-orbit. All the ACOP maintenance operations are safe in accordance with NSTS 18798B Interpretation Letter MA2-00-038.

The following types of maintenance have been identified and are described in the following paragraphs:

- pre-launch maintenance
- pre- and post-installation maintenance
- preventive maintenance (nominal operations)
- post-failure maintenance (non-nominal operations)

Only maintenance requirements and basic assumptions relative to maintenance are described. Details about operations planned in this document can be found in the ACOP Operational Report.

In some cases preventive and post-failure maintenance requires the replacements of items installed inside ACOP. In the design of such items particular attention has been used in order to minimize the complexity of the necessary activities and reduce the effort requested to the ISS crew for performing the requested operations. The spare parts will be stowed in a soft stowage bag. The following items have been designed as replaceable units:

- Hard disk drives
- CompactPCI boards
- Power supply board
- Fan assemblies
- Dust screens

3.1 PRE-LAUNCH MAINTENANCE

This paragraph refers to the ground only operations that will occur after payload processing at KSC just before launch. Other ground maintenance operations correspond to the ones foreseen on-orbit for preventive and post-failure maintenance and will be performed on-ground when requested during ACOP test and processing phases.

Other than the standard pre-launch operations for EXPRESS Rack payloads, at the moment the only operation foreseen on ACOP before launch is the replacement of the captive fasteners use to fasten ACOP to the rack. The reason is that, due to the fasteners secondary locking mechanism, the part is only certified for five insertions. Since the number of insertions for on-ground test can be expected as higher than five, the baseline is to replace the fasteners before the launch so that ACOP will be launched with fresh captive fasteners.

3.2 PRE- AND POST-INSTALLATION MAINTENANCE

Once on-orbit aboard the ISS, standard procedure will be followed for ACOP insertion into the assigned location in the EXPRESS Rack. The ACOP will be installed into a US-LAB ISPR by the crew using the standard locker insertion tool to secure the four captive mounting fasteners in the rear of ACOP to the EXPRESS rack back plate.

In addition to the standard operations to insert ACOP in the rack and fasten the locker to the rack back plate, the following activities shall be performed according to ACOP specific design:

1) **Pre-installation**
   - Visual check (no visible damages)
   - Inspection on cooling air inlet and outlet dust screens cleanliness and integrity (screens are located in the ACOP back plate and must be checked before ACOP is inserted in the rack)

2) **Post-installation**
   - Removal of any installed launch lock

- Hard disk drives insertion: 4 hard drives will be taken from the stock available on the ISS (launched with ACOP in a soft stowage bag) and inserted in the available slots
- External cables installation

3.3 PREVENTIVE MAINTENANCE

This section includes the following activities to be implemented on ACOP during its operative life aboard the ISS:

- First commissioning check after installation
- Nominal operations

3.3.1 FIRST COMMISSIONING CHECK AFTER INSTALLATION

After first ACOP turning-on, all the functions will be checked by means of dedicated SW routines to verify no malfunctions occur. Since ACOP is basically a ground-operated payload, no effort is required to the astronauts in this phase, except for some visual checks (to the status information available on ACOP Front Panel) to be performed after ground control request (TBC).

3.3.2 NOMINAL OPERATIONS

During ACOP operative life aboard the ISS, the following nominal operations will be performed:

1) **Hard disk drives exchange**
   The hard drives installed in ACOP require periodic replacement by the ISS crew from the onboard stock of empty drives to enable ACOP to record all of AMS-02's data onto fresh hard drives. Once recorded, data will not be overwritten; rather they will be transported to ground as a permanent archive.

2) **Inspection and cleaning of the inlet and outlet dust screens**
   As determined necessary ACOP shall be removed from the ISPR and the dust screens inspected and, if required, cleaned. The base line plan is:
   - After 60 days of service ACOP will be removed from the EXPRESS rack for inspection and cleaning of the inlet and outlet dust screens located on the back plate.
     The crew shall provide the ACOP team with an assessment of cleanliness of the dust screens and then remove as much residue as possible using sticky tape and/or a vacuum cleaner.
   - Subsequently repeat this inspection and cleaning twice annually, subject to the observed cleanliness of the AAA system.
   - Operationally the ACOP POCC will be monitoring the ACOP thermal profile. Any dust screen blockage will result in a temperature rise. In the event of an unexplained thermal rise the ACOP POCC will request a prompt diagnostic inspection by the crew of both the dust screens and fans. After the diagnostics the dust screens will be cleaned.

   Note: there is no specification available to date defining the cleanliness of the AAA airflow nor is there any operational experience with rear breathing EXPRESS rack experiments.

3) **Software upgrade**
   The software upgrade will be performed by using a USB storage device inserted by the crew in the USB connector on ACOP Locker Front Panel. This infrequent activity is considered nominal. The crew will power off ACOP, insert the USB key and power on ACOP. Activity will be monitored by the crew on the LCD display and the crew will be requested to verify that the upgrade occurred. Following a successful upgrade ACOP will be powered off, the USB key removed, and power restored

3.4 POST-FAILURE MAINTENANCE

3.4.1 FAILURE AND FAULT DIAGNOSIS

ACOP provides support for identification of failures; in particular ACOP provides a set of measurements (analogue/digital) to allow the user to compare the expected values against the measured ones. Failure detection is mainly by means of software: since ACOP is a ground operated experiment, failure and fault diagnosis will managed by the control center on-ground. The crew will be notified by voice loop from the ground if their attentions will be necessary.

There are hardware protections present inside ACOP (over-current, over-voltage, over-temperature). Some of these protections have indicators on the front of the printed circuit boards inside the ACOP door. In the unlikely event of a fault or failure the crew will be asked to support diagnosis of the problem.

Details about failures identification are reported in the ACOP Failure Modes, Effects and Criticality Analysis (FMECA).

3.4.2 FAILURE AND FAULT RECOVERY

The fault recovery is a power off/on cycle, thus resetting ACOP in its default condition.

If a complete failure occurs and it can not be recovered by means of a power off/on cycle, the recovery is a replacement of the failed part at board level from the set of spare parts kitted within the soft stowage bag. In particular, the following parts can be replaced in case of failure:

1) **Hard disk drives**

2) **CompactPCI boards and power board**
   This activity shall be performed in case either a failure on a board occurs or an upgrade of the hardware is required. The activity will be performed with the ACOP powered down and according to a specific plan that clearly will define the procedure steps.

3) **Fans and screens**
   In the unlikely event a fan fails in ACOP it will be possible to replace the fan on orbit. The operation involves the removal of the ACOP Locker from the EXPRESS rack, unfastening the fan assembly, disconnecting the fan power, then reversing these steps to install a replacement fan assembly available in the stowed spares kit.